NAVY SBIR/STTR
Full Topic Development Template and Guidance

Delete <instructions> as each section is completed
Solicitation <Solicitation Number> **Program: SBIR**
SYSCOM: ONR **SPONSOR:** Code (b) (6)

TOPIC NUMBER: <system generated by Navy Topic Review site>

TITLE: Nickel Aluminum Bronze for Additive Manufacturing Alloy Development

TECHNOLOGY AREA: *MATERIALS/PROCESSES*

MANUFACTURING TOPIC: Yes or No.

AFFORDABILITY: (not published)
Does this topic address affordability? Yes
Note on Cost Impact: If the answer to the above question is "yes," the topic description should show how the proposed technology is expected to impact system-level (e.g., propulsion, weapon systems, etc.) cost in the categories below. The answers should be consistent. For example, if the topic does address affordability, then there should be a reduction listed for some of those areas and the aggregate.
(a) Acquisition: Reduction
(b) Maintenance: Reduction
(c) Manning: No Impact
(d) Operation (Excluding Manning): No Impact
(e) Aggregate of the above four: *Reduction*
Note on Energy Targets: The Navy has identified five Energy Targets to reduce energy consumption and improve national security. Towards meeting these target goals, a DoN SBIR/STTR initiative requests topics addressing one or more of the following: (i) alternative energy (e.g., solar, geothermal, wind, ocean energy; energy scavenging, landfill gas, waste-based energy), (ii) biofuels, and (iii) energy efficiency (e.g., hybrid electric power, fuel cells, high efficiency power conversion, power grid metering/smart grid, high efficiency HVAC, maintenance reduction systems, efficient propulsion systems, drag reduction coatings and appendages, anti-corrosion coatings). If the topic supports the energy targets, that support must be discussed in the description.

ENERGY TARGETS: (not published)
What energy target does this topic support? None

Note on Future Naval Capability (FNC): If the answer to the question below is yes, then the FNC must be listed under the "Acquisition Program, Program of Record, or FNC" section of the topic. A description of FNC's can be accessed on the Office of Naval Research (ONR) website at http://www.onr.navy.mil/science-technology/directorates/transition/future-naval-capabilities-fnc.aspx.

FUTURE NAVAL CAPABILITY (FNC) TOPIC: (not published)
Does this topic address an FNC? Yes

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ACQUISITION PROGRAM: EPE-17-03 Quality Metal Additive Manufacturing (Quality Made).

ACQUISTION POINT OF CONTACT:

ACQUISTION INTEREST: (not published)
This SBIR topic directly supports the Quality Made FNC program. Quality Made has support from PEO Ships, PEO(A) and PEO (LS).

SEA 073 - Undersea Technology (Preparing for the Next Generation Attack Submarine) has identified that future geometries to achieve desired performance for the Next Generation SSN propulsor will be highly complex for conventional casting and machining of nickel aluminum bronze, a preferred material for propulsors. Alternative materials and manufacturing technologies are of interest to increase the potential design space for the Next Generation SSN propulsor.

OBJECTIVE: Develop, optimize and demonstrate use of a nickel aluminum bronze (NAB) alloy composition optimized for the additive manufacturing process for large seawater components (>12"). The alloy must exceed the current mechanical and seawater corrosion resistance of cast NAB alloy C95800.

DESCRIPTION: The Navy extensively uses components of cast nickel aluminum bronze (NAB) in sea-water applications for their combination of strength, toughness, and corrosion resistance. Commonly used for large scale, small-production-quantity castings, NAB is challenging to consistently cast in complex geometries and in thin sections. Additive manufacturing (AM) allows for layer by layer fabrication from a digital design, and offers significant opportunities for complex geometries that may be difficult to achieve in a traditional casting.

Direct fabrication of AM components has been demonstrated with a wide variety of materials and technologies. Current bronze and copper alloys for AM often utilize post processing and impregnation for final part fabrication. There has been limited work in direct AM fabrication of bronze; however, efforts have focused on utilization of traditional casting compositions or welding analogs. Cast NAB alloys (ASTM B 148, UNS C95800) are generally slow cooled and precipitation strengthened, which may not be ideal for the rapid heating-cooling associated with direct AM fabrication. Additive manufacturing can have cooling rates >1000 °C/s and unique processing conditions due to the cyclic heating/cooling in localized areas during fabrication. Similarly, conventional welding of NAB can result in severe distortion due to residual stress and residual stresses may be further exacerbated in the AM process. Lastly, cast NAB has significant natural seawater corrosion resistance, but introduction of microstructural variation in the AM process may result in changes in corrosion behavior.

These considerations for layer by layer fabrication can be increasingly complex for large scale components >12". To realize fully the capabilities of AM, new NAB alloys for large scale fabrication must be developed specifically for the additive manufacturing process to enhance strength and ductility compared to traditional cast NAB, while maintaining corrosion resistance.

PHASE I: <
During Phase I, the small business will define and develop a concept/approach using computational tools for a new/optimized nickel aluminum bronze alloy composition for AM, targeting initial mechanical properties (modulus, etc.) and effects on microstructure and phase precipitation as a function of thermal processing (heating/cooling rate). If awarded the Phase I option, the small business will demonstrate the feasibility of a new/optimized composition for feedstock material amenable to the additive manufacturing process on the small coupon level.

PHASE II: Based on Phase I results, the Phase II effort will develop, demonstrate and validate the proposed computational approach for new/optimized AM NAB composition(s). This will include demonstrating optimized alloy composition(s) in AM fabrication of large test builds >12" to obtain as-fabricated mechanical properties and microstructural/chemical characterization. Mechanical properties such strength, ductility, toughness, fatigue, etc. will be tested; distortion relative to the original test build CAD drawing will be measured. Microstructural/ chemical characterization such as grain size, porosity, phase identification/quantification, precipitate formation/segregation, chemical segregation, electrochemical response, etc. will be measured for the new/optimized AM NAB composition(s). Conventional "as-cast" NAB will serve as the baseline for fabrication/processing and material property improvement. The performer shall demonstrate strength/ductility and corrosion equivalent or superior to cast UNS C95800 properties. It is recommended that the performer work with bulk material vendors/OEMs to facilitate transition for Phase III.

PHASE III DUAL USE APPLICATIONS: Phase III will transition optimized alloy composition to commercial suppliers through bulk material vendors, OEMS, or other partnering agreement. Phase III will demonstrate AM optimized NAB alloy(s) and transition an AM technical data package to Warfare Centers and other DoD production/maintenance facilities.

REFERENCES:

1. Howell, Paul R. On the Phases, Microconstituents and Microstructures in Nickel-Aluminum Bronze.
2. Wong, Kaufui V. and Hernandez, Aldo. A Review of Additive Manufacturing. doi:10.5402/2012/208760
3. ASTM B 148

KEYWORDS: additive manufacturing; casting; bronze; nickel aluminum bronze; sea water components; alloy development

ITAR: Note that an "ITAR restricted" topic does not imply that a foreign citizen cannot participate in the related research. It merely implies that a foreign citizen on a temporary visa

(e.g., a student visa or exchange visa) is excluded. Generally, a foreign citizen employed in the U.S. has Permanent Resident status and he or she can participate in "ITAR restricted" research**.**

Is this topic ITAR Restricted? No

1) Will the resulting technology have civil applications? Yes
2) Will the resulting technology have performance equivalence in civil applications? Yes
3) Will the resulting technology have significant military or intelligence applicability? Yes
4) Is the technology being developed a defense article on the U.S. Munitions List (USML)? No
5) If not a defense article listed on the USML, will the technology be an integral component or piece of supporting equipment for an item listed on the USML? *No*
6) Will the technology development result in an end product (usable item not just reports or documentation) that is classified? No
7) Are there other reasons why the disclosure of this technology could be damaging to national security? For example, disclosure of current USML related capabilities. *No*

DOES THIS TOPIC MEET THE DoN TOPIC CRITERIA? (If you have satisfied the criteria in the guidance section, then you have met DoN Criteria) Yes

SECURITY REVIEW:

1) Are any unusual capabilities, vulnerabilities, or other sensitive critical information being revealed? Choose an item.
2) Are there any critical items of information or indicators contained in the topic? Choose an item.
3) Are there any risks associated with the release of any of this information? Choose an item.
4) Are clues to sensitive information in another program included? Choose an item.
5) Will work under this effort be classified in Phase I? Choose an item.
6) Is it probable that the work under this effort will be classified under Phase II? (Yes is acceptable but secure access should be noted under Phase II.) Choose an item.
7) Is any of the information to be included in the DoD SBIR/STTR Program Solicitation classified? Choose an item.

NAVY NEED: NAB is a naval alloy of interest heavily used in marine systems. Additive manufacturing can enable a wider design space, but is currently limited in available alloys. There has been limited work in direct AM fabrication of NAB.

MISSION CAPABILITY, PERFORMANCE AND LIFE CYCLE COST: This topic will enable increased performance through new designs that leverage AM manufacturing technology for a marine alloy.

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